DOE Heavy Vehicle Aerodynamic Drag Project

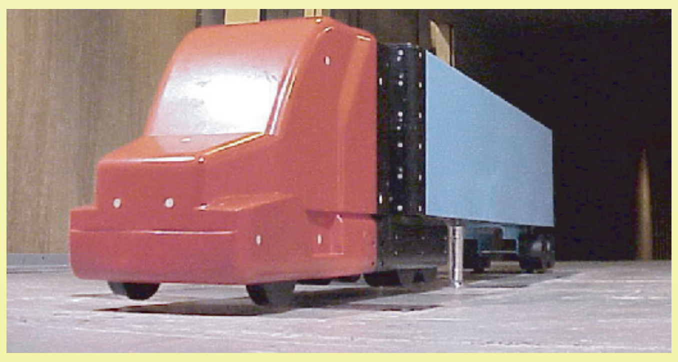
At 70 miles per hour, a common highway speed today, overcoming aerodynamic drag represents 65% of the engine's total energy expenditure for a typical heavy truck vehicle. Reduced fuel consumption for heavy vehicles can be achieved by altering truck shapes to decrease the aerodynamic resistance (drag). It is conceivable that present day truck drag coefficients can be reduced by as much as 50%.

The U.S. Department of Energy (DOE) Energy Efficiency and Renewable Energy, Office of FreedomCAR & Vehicle Technologies, is supporting a consortium effort with representatives from DOE National Laboratories, NASA, and universities to reduce fuel consumption by reducing the aerodynamic drag on heavy vehicles. DOE encourages industry participation and involvement in the consortium from both tractor and trailer manufacturers and fleet operators, because of the well-recognized importance of integrating the tractor and trailer for reduction of aerodynamic drag and the desire to apply these advanced technologies.

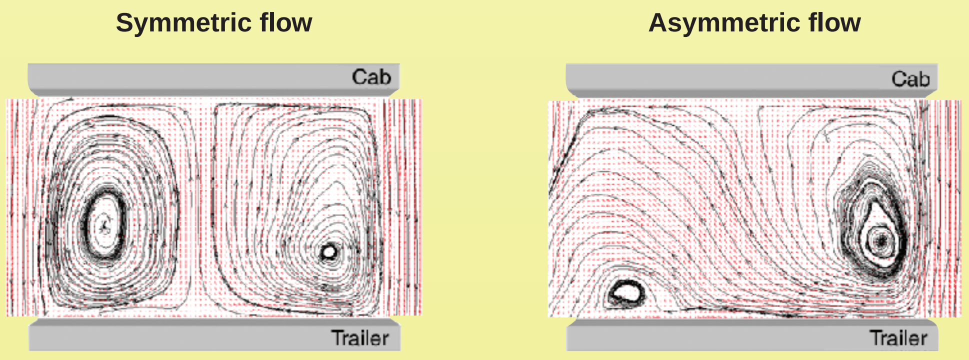
The goal of the proposed activities is to develop and demonstrate the ability to simulate and analyze aerodynamic flow around heavy truck vehicles using existing and advanced computational fluid dynamics (CFD) tools. Activities include an extensive experimental effort and the development and demonstration of new concepts and technologies for aerodynamic drag reducing devices. The final products are an experimental data base and validated CFD methods as tools to be used to reduce aerodynamic drag of heavy truck vehicles and thus improve their fuel efficiency and reduce emissions.

Experiments on models of generic and integrated tractor-trailers are underway at NASA Ames Research Center (NASA) in Moffett Field, California, the University of Southern California (USC) in Los Angeles, California, and Georgia Tech Research Institute (GTRI), in Atlanta, Georgia. Companion computer simulations are being performed by Lawrence Livermore National Laboratory (LLNL) in Livermore, California, Sandia National Laboratories (SNL) in Albuquerque, New Mexico, California Institute of Technology (Caltech) in Pasadena, California, and Argonne National Laboratory (ANL), in Argonne, Illinois. USC, LLNL, and GTRI are developing devices for reducing aerodynamic base drag.

Consortium members in NASA Ames Research Center 12-foot pressure wind tunnel.

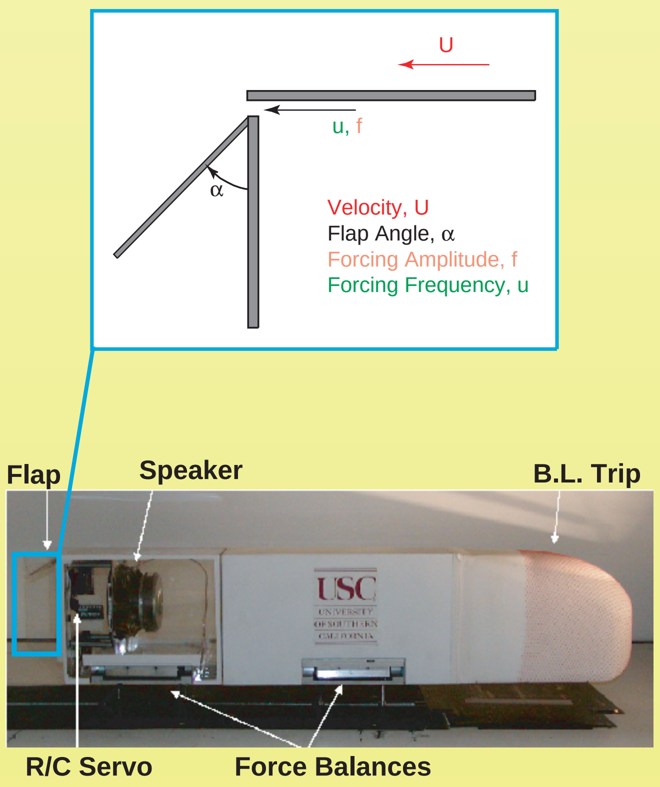


Experiments on a generic conventional truck with boattail plates, side extenders, and under-slung cargo at NASA Ames includes 476 pressure taps, particle image velocimetry (PIV) in the tractor-trailer gap and in the trailer wake, oil film interferometry (OIF) for measuring skin friction, unsteady pressure transducers at rear of the tractor, at the front and the back of the trailer, and independent measurement of tractor and vehicle drag.

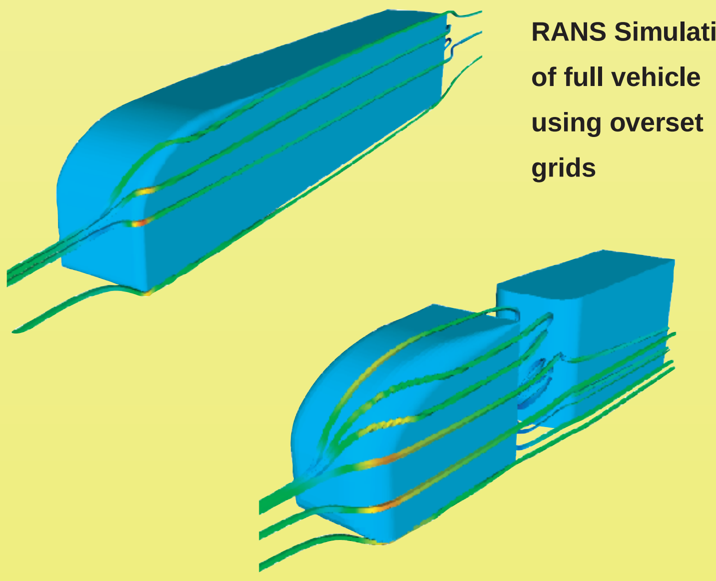


Time-averaged streamline patterns, normalized gap width, G/L=55%

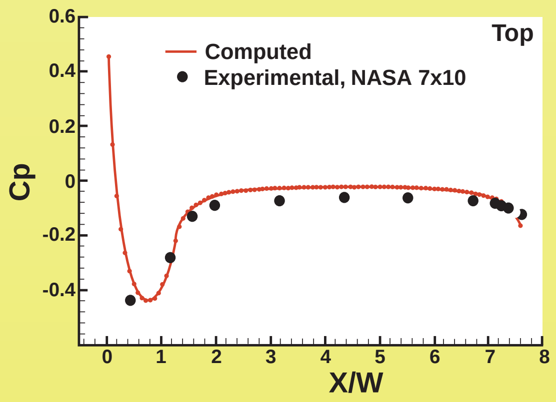
USC has found experimentally that a critical tractor-trailer gap exists at $G/L \approx 0.5$. For $G/L \leq 0.5$, the gap flow consists of a relatively stable, symmetric toroidal vortex with a relatively low drag. For $G/L \geq 0.5$, the gap cannot support the steady vortex and the vortex alternately sheds from the gap region, in an unsteady fashion. The relatively smooth flow about the trailer (and tractor) is disrupted, and a large drag results. These studies can provide direction on the effect of cab extenders and the presence of refrigeration units.

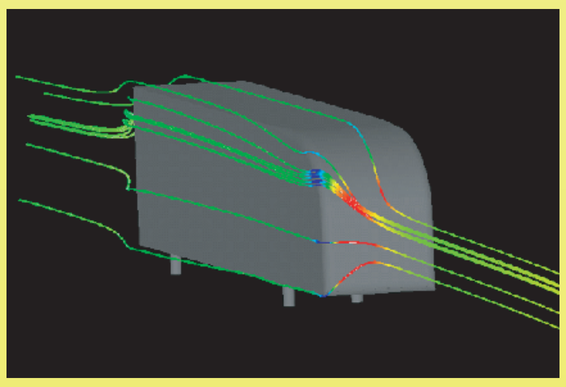


USC has developed and is testing an oscillation device to control the trailer wake flow. The device is intended to alter the turbulent structure of the wake, resulting in a drag reduction.

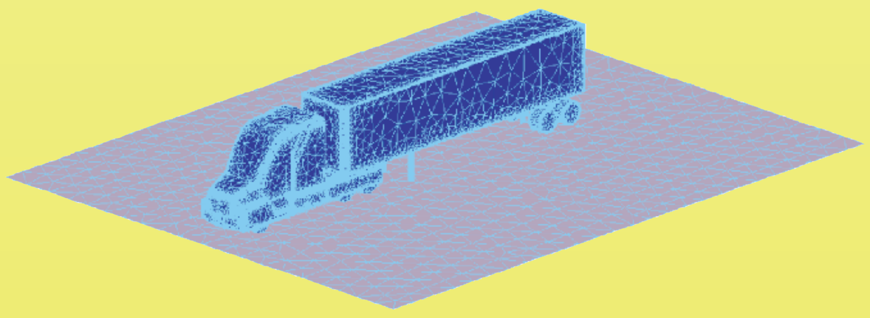


RANS Simulation of full vehicle using overset grids

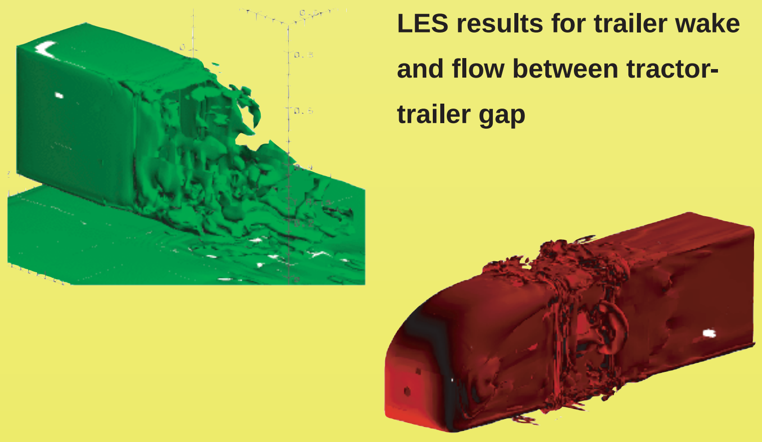




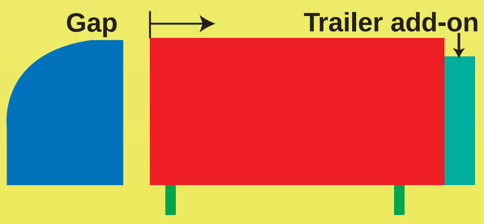
SNL is investigating four different Reynolds-averaged Navier Stokes (RANS) computational models for simulation of a tractor-trailer configuration for transfer of this information to industry as guidance in their simulation process. The RANS calculations do compare well with experiment except for the calculated pressure at the edges of the trailer base, which is essential for correctly determining the vehicle drag.



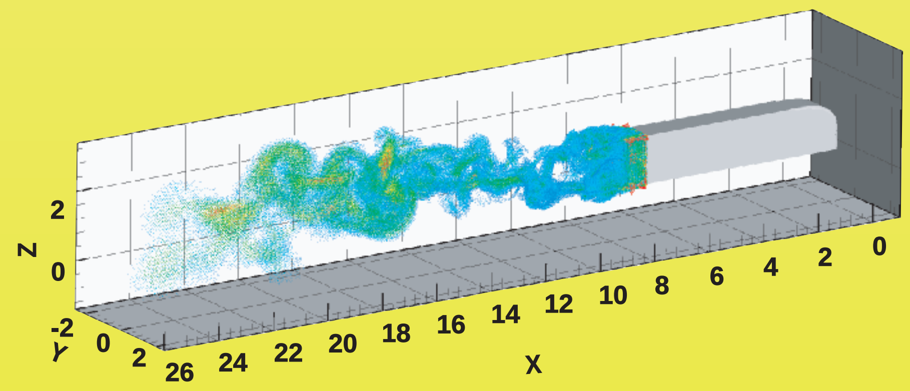
ANL is investigating application of commercial codes on the generic conventional truck model.



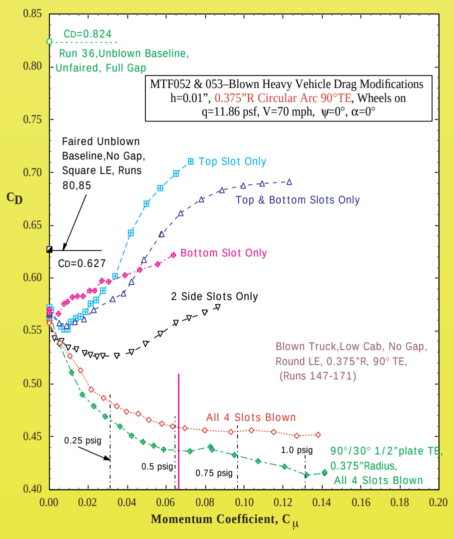
LES results for trailer wake and flow between tractor-trailer gap



LLNL is generating Large-Eddy Simulation (LES) results for direct comparison to the NASA experimental data and the RANS simulation performed by SNL. NASA's overset grid code is also being used by LLNL. This complimentary work should be of interest to industry, because it will supply them with some near term guidance on the adequacy of various turbulence models for application to predicting the frontal gap and base drag on a tractor-trailer.



Caltech is simulating a tractor-trailer configuration using a grid-free Vortex Method with improved, fast, parallelized, adaptive techniques. This benefit is of interest to industry because quick response times are needed when using computational tools for design guidance.



GTRI has performed wind tunnel and full-scale tests in evaluation of the fuel economy of a pneumatic device for reducing separated flow fields and decreasing base pressure drag.

NASA Ames Research Center, University of Southern California, Lawrence Livermore National Laboratory, Sandia National Laboratories, California Institute of Technology, Argonne National Laboratory, Georgia Tech Research Institute